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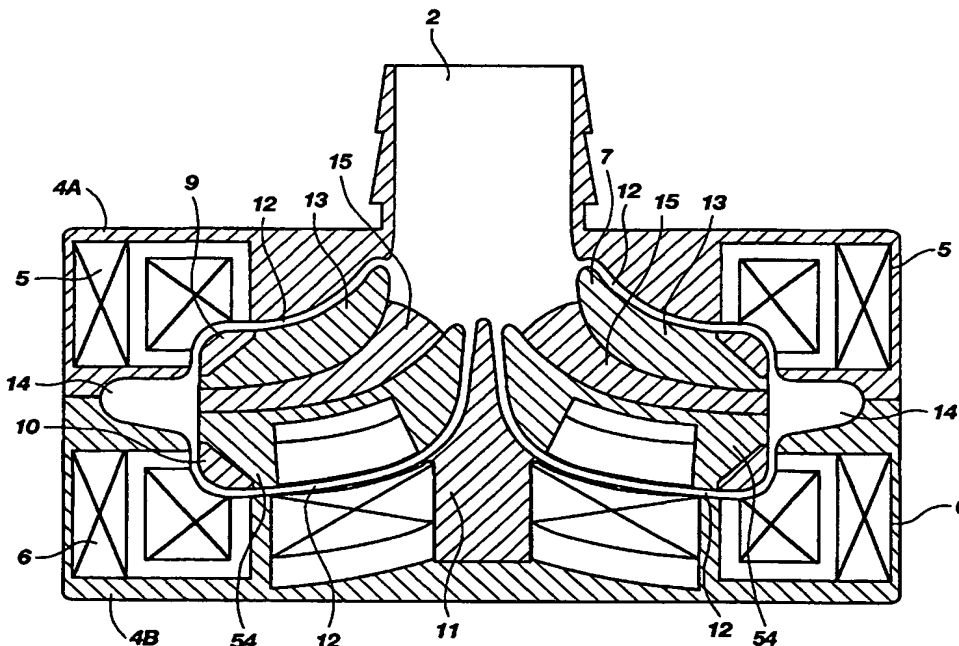
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(54) Title: IMPLANTABLE CENTRIFUGAL BLOOD PUMP WITH HYBRID MAGNETIC BEARINGS

(57) Abstract

A pump for pumping sensitive fluids, such as blood, having no mechanical contact between the impeller and any other structure. The pump comprises a pump housing, an impeller disposed within the pump housing, a magnetic bearing system for supporting and stabilizing the impeller in five degrees of freedom, and a conformally shaped magnetically linked motor for rotating the impeller. The magnetic bearing system and motor advantageously comprise electromagnets and permanent magnets for stability and control of the impeller, and to reduce size, weight, and pump power consumption. Permanent and electromagnets are disposed on the pump housing and permanent magnets are disposed on the impeller such that by controlling electric current through the electromagnets on the housing, the magnetically suspended impeller

functions as the rotor, and the housing as the stator of a D.C. motor. The system advantageously allows for sensing of relative impeller position and dynamic properties without the need for additional sensors. The fluid inlet, pump impeller, housing, and other components are configured such that flow patterns are as smooth and laminar as possible to reduce damage to the fluid, and such that eddies, flow separation, and re-circulation are reduced. In various embodiments, the pump is suitable for short or long-term implantation as a ventricular assist device or as a complete replacement heart in a human patient.



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